ARTÍCULOS SOBRE TRABAJOS RECIENTES DEDICADOS A IDENTIFICAR MONOPOLOS MAGNÉTICOS

C. Castelnovo, R. Moessner, S. L. Sondhi, "Magnetic monopoles in spin ice," Nature 451: 42-45, 3 January 2008.

Electrically charged particles, such as the electron, are ubiquitous. In contrast, no elementary particles with a net magnetic charge have ever been observed, despite intensive and prolonged searches. We pursue an alternative strategy, namely that of realizing them not as elementary but rather as emergent particles—that is, as manifestations of the correlations present in a strongly interacting many-body system. The most prominent examples of emergent quasiparticles are the ones with fractional electric charge *e*/3 in quantum Hall physics. Here we propose that magnetic monopoles emerge in a class of exotic magnets known collectively as spin ice: the dipole moment of the underlying electronic degrees of freedom fractionalises into monopoles. This would account for a mysterious phase transition observed experimentally in spin ice in a magnetic field, which is a liquid-gas transition of the magnetic monopoles. These monopoles can also be detected by other means, for example, in an experiment modelled after the Stanford magnetic monopole search.

D. J. P. Morris et al. "Dirac Strings and Magnetic Monopoles in Spin Ice Dy2Ti2O7," Science Express, Published Online September 3, 2009.

Sources of magnetic fields—magnetic monopoles—have so far proven elusive as elementary particles. Condensed-matter physicists have recently proposed several scenarios of emergent quasiparticles resembling monopoles. A particularly simple proposition pertains to spin ice on the highly frustrated pyrochlore lattice. The spin-ice state is argued to be well described by networks of aligned dipoles resembling solenoidal tubes—classical, and observable, versions of a Dirac string. Where these tubes end, the resulting defects look like magnetic monopoles. We demonstrated, by diffuse neutron scattering, the presence of such strings in the spin ice dysprosium titanate ($Dy_2Ti_2O_7$). This is achieved by applying a symmetry-breaking magnetic field with which we can manipulate the density and orientation of the strings. In turn, heat capacity is described by a gas of magnetic monopoles interacting via a magnetic Coulomb interaction.

T. Fennell et al. "Magnetic Coulomb Phase in the Spin Ice Ho2Ti2O7," Science Express, Published Online September 3, 2009.

Spin-ice materials are magnetic substances in which the spin directions map onto hydrogen positions in water ice. Their low-temperature magnetic state has been predicted to be a phase that obeys a Gauss' law and supports magnetic monopole excitations: in short, a Coulomb phase. We used polarized neutron scattering to show that the spin-ice material $Ho_2Ti_2O_7$ exhibits an almost perfect Coulomb phase. Our result proves the existence of such phases in magnetic materials and strongly supports the magnetic monopole theory of spin ice.

S. T. Bramwell et al. "Magnetic Charge Transport," ArXiv, Submitted on 6 Jul 2009,

It has recently been predicted that certain magnetic materials contain mobile magnetic charges or `monopoles'. Here we address the question of whether these magnetic charges and their associated currents (`magnetricity') can be directly measured in experiment, without recourse to any material-specific theory. By mapping the problem onto Onsager's theory of weak electrolytes, we show that this is possible, and devise an appropriate method. Then, using muon spin rotation as a convenient local probe, we apply the method to a real material: the spin ice $Dy_2Ti_2O_7$. Our experimental measurements prove that magnetic charges exist in this material, interact via a Coulomb interaction, and have measurable currents. We further characterise deviations from Ohm's Law, and determine the elementary unit of magnetic charge to be 5 ﬁB per Angstrom, which is equal to that predicted by Castelnovo, Moessner and Sondhi using the microscopic theory of spin ice. Our demonstration of magnetic charge transport has both conceptual and technological implications.

Hiroaki Kadowaki et al. "Observation of Magnetic Monopoles in Spin Ice," ArXiv, Submitted on 25 Aug 2009

From the symmetry of Maxwell's equations of electromagnetism as well as field theoretical arguments, magnetic charges or monopoles would be expected to exist. But magnetic monopoles have never been observed despite longstanding experimental searches. Recently, attention has turned to condensed matter systems where tractable analogs of magnetic monopoles might be found, and one prediction is for an emergent elementary excitation in the spin ice compound, where the strongly competing magnetic interactions exhibit the same type of frustration as water ice. We directly probe the monopoles in spin ice using neutrons, and show that they interact via the magnetic Coulomb force. Specific heat measurements show that the density of monopoles can be controlled by temperature and magnetic field, with the density following the expected Arrhenius law.